THE RESTORATION PROJECTS IN THUNDER BAY AND FURTHER DEVELOPMENT

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THE RESTORATION PROJECTS IN THUNDER BAY AND THEIR FURTHER BENEFITS

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ABSTRACT

Yifu, Y. 2019. THE RESTORATION PROJECTS IN THUNDER BAY AND FURTHER DEVELOPMENT. 70 Pp.

Keywords: Restoration, Thunder Bay, Lakehead Region Conservation Authority, Mission Island Marsh, Shoreline erosion, Landfill…

Ecological restoration is the scientific study and process that restore the ecosystem's functions and services by field study and planning in order to enhance the value of the ecosystem and sites return to society. The restoration progress in Thunder Bay is undergoes an early stage compared with southern Ontario. The four restoration projects and plans of this study were all initiate under the Great Lakes Water Quality Agreement, Thunder Bay Area of Concern. With the study of City of Thunder Bay Offcial Plan, 2002, a general idea of future development of restorations in Thuder Bay is gained. There will be a increasingly number of restoration projects within 20 years, and the majority of the restorations will focus on the stormwater management and watershed protection.

This thesis will begin with the introduction of four restoration projects and plans: McVicar Creek Protection & Rehabilitation Plan, City of Thunder Bay Stormwater Management Plan, George Creek Brook Trout Rehabilitation Project, Mission Island Marsh Conservation Area Master Plan; and delinate the land use policy in the City of Thunder Bay. Followed with the discussion of the further development of restoration activities in the area.

ACKNOWLEDGMENT

First of all, I would like to express my special thanks of gratitude to my supervisor Dr. Jian Wang who supports me on my thesis about restoration by advising me with the perfect direction and instruction. Secondly, I would thank Ms. Gail from Lakehead Region Conservation Authority and Mr. Schwar from City of Thunder Bay, they kindly share all the data and information I need and also assist me with lots of excellent ideas for my research. Lastly, I would give my appreciation to my girlfriend Kaiyue, who has always supported me while I am working on my thesis.

INTRODUCTION

The rapid development of industry and expansion of human population result in massive transformation of landscape and degradation of ecosystem. Many people recognize that biodiversity has an intrinsic value and that we have a responsibility to conserve it for future generation (Costanza et al. 1997). Natural ecosystems provide ecosystem services in the form of resources such as food, fuel, and timber; the purification of air and water; the detoxification and decomposition of wastes; the regulation of climate; the regeneration of soil fertility; and the pollination of crops. These ecosystem processes have been estimated to the worth trillions of dollars annually (Daily 1997). Due to the increasing intensity of human activities, both species extinction and ecosystem service decline are in a serious situation, thus the conservation of ecosystem become critical for sustainable development of the society. Habitat loss is the leading cause of both species' extinctions and ecosystem service decline (Daily 1997). Two methods have been identified to slow the rate of species extinction and ecosystem service decline, they are the conservation of currently viable habitat and the restoration of degraded habitat. The commercial applications of ecological restoration have increased exponentially in recent years (Young et al. 2005).

The objective of ecological restoration is to restore the human transformed, degrade ecosystem, in order to achieve the revivification of ecosystem services. The goals of restoration describe the desired future condition of a site, often decades into the future. These long-term goals are supported with more short-term objectives or targets. When establishing these goals and objectives, it is important to have an understanding of

the goals and objectives, it is important to have an understanding of the scale of restoration that taking consideration of ecosystem processes, habitat, and individual species; processes of ecological succession; and the concepts of natural disturbance regimes; and the natural range of variability. Considering natural healing processes, natural disturbance, and expected variability over time and space will help ensure that restoration prescriptions are appropriate for the site and the landscape. Restoration objectives are these measurable components within the processes to achieve the goals such as biodiversity, water, air qualities, and the succession stage of the ecosystem (Thomson 1996). As a social activity, an ecological restoration project should have consideration of many aspects including the need of society; costs; benefits; science-practice gap; and the benefits return period.

LITERATURE REVIEW

The literature search about Mission Island Marsh was provided by Ms. Gail from Lakehead Region Conservation Authority with the aim of providing specific details about the historical background, goals and objective, site inventory and land use information. (Mission Island Marsh Conservation Area, Master Plan, 1994)

The literature search about stormwater management plan was provided by Mr. Werner Schwar from the City of Thunder Bay. The provided literature included Thunder Bay Stormwater Management Plan Volume I-III and the construction blueprint of Winnipeg Avenue Green Infrastructure.

The literature search about The George Creek Restoration Project was also provided by Mr. Werner Schwar, and a thesis that was produced from the monitoring work on George Creek was provided by Dr. Robert Stewart and Mr. Michael Barten from Lakehead University.

By introducing the Thunder Bay Official Plan, a better understanding of the land use strategy in Thunder Bay is provided.

DEFINITIONS

Restoration Ecology

Restoration ecology is the academic study of the process, whereas ecological restoration is the actual project or process by restoration practitioners. The Society for Ecological Restoration defines "ecological restoration" as an "intentional activity that initiates or accelerates the recovery of an ecosystem with respect to its health, integrity and sustainability" (Society for Ecological Restoration International Science & Policy Working Group, 2004). Ecological restoration includes a wide scope of projects including erosion control, reforestation, removal of non-native species and weeds, revegetation of disturbed areas, daylighting streams, reintroduction of native species, and habitat and range improvement for targeted species (Pimm et al. 1995).

Adaptive Management

Adaptive management is a structured, iterative process of robust decision making in the face of uncertainty, with air to reducing uncertainty over time via system monitoring. In this way, decision making simultaneously meets one or more resources management objectives and, either passively or actively, accrues information needed to improve future management. (Holling, 1978)

Best Management Practice (BMP)

Is a management approach where objectives are set, monitoring is implemented and results are compared against objectives understanding that management strategies may be adjusted as necessary to attain the overall objective.

Total Suspended Solids (TSS)

Total suspended solids are particles that are larger than 2 microns found in the water column. The solids include anything drifting or floating in the water, form sediments, silt, and sand to plankton and algae. (Wetzel, 2001)

Areas of Concern (AOC)

The locations within the Great Lakes identified as having experienced high levels of environmental harm.

Under the 1987 Great Lakes Water Quality Agreement between Canada and the United States, 43 such areas were identified, 12 of which were Canadian and 5 of which were shared binationally. (Government of Canada 2014)

Figure 2 illustrates the locations of areas of concern within the Great Lakes region.

Provincially significant wetlands (PSWs)

Wetlands are among the most productive diverse habitats on the planet. Provincially Significant Wetlands are those areas identified by the province as being the most valuable. They are determined by a science-based ranking system known as the Ontario Wetland Evaluation System (OWES). This Ministry of Natural Resources framework provides a standardized method of assessing wetland functions and societal values, which enables the province to rank wetlands relative to one another. Ontario has an estimated 23 million to 29 million hectares of wetlands. This represents approximately 25% of Canada's wetlands, or about 6% of Earth's wetlands. Most of Ontario's wetlands are found in the northern part of the province. (OMNR)

GLOSSARY

CITY OF THUNDER BAY

The City of Thunder Bay is located in northwestern Ontario, Canada. It is the most populous municipality in Northwestern Ontario. Thunder Bay used to be the major city of transportation that linked between Winnipeg and Southern Ontario. After a period of extraordinary growth in the 20th Century, Thunder Bay has experienced many adverse environmental impacts due to the development of industry and lack of attention paid to the environment. The sustainable development and environmental management has become the mean approach of the City of Thunder Bay nowadays. The City's 2015-2018 Corporate Strategic Plan determines four goals with the principle of sustainable development and sustainable management of environment: Leader in accessible recreation and services for all people; Clean and beautiful streets and spaces; Leader in climate change adaption; Greener with protected and enhanced natural areas.

STORMWATER MANAGEMENT PLAN

With the principle of achieving a sustainable environment, the City of Thunder Bay has developed a Stormwater Management Plan. The plan focuses on the stormwater system, and how changes in the environment, land use, and climate affect it. The plan will spread over 20 years, and it will look for opportunities to assess and improve current infrastructure.

In urban areas, impervious, or hard, surfaces such as asphalt, concrete, and rooftops, prevent stormwater from naturally soaking into the ground. Instead, the water runs quickly into storm drains and sewer systems, and then to our lakes and rivers. These hard surface areas create more stormwater runoff, which carries more pollutants, such as oil,

grit, and garbage into lakes and rivers. The Stormwater Management Plan is to guide the City of Thunder Bay in the development of an integrated stormwater management program. It provides an assessment of existing stormwater systems recognizing the inter-relationship with natural systems (creeks, wetlands, and open spaces), existing infrastructure and land uses, as well as the hydrology cycle (surface water/ groundwater interactions). It also recognized the City's efforts to address the impacts of climate changes by highlighting those stormwater management activities that provide a direct benefit for climate adaptation.

THE MISSION ISLAND

The development of the Thunder Bay waterfront has been occurring for nearly 100 years. Construction of existing breakwall and the first grain elevator began in the late 1800s. Since then, shoreline alteration and development have led to the existing harbor installations which handle a variety of commodities including grain, iron ore, steel products, coal, potash, Sulphur, forest products and petroleum (Lakehead Harbour Commission, 1982). The northeast corner of Mission Island was used by the City as a dump for over 20 years until 1965 but has since been closed and capped with earth fill (Beak, 1980). In 1958, Ontario Hydro began clearing the southern tip of the island for the construction of a 100MW coal-fired generating station. A significant portion of the land was reclaimed from Lake Superior. Construction of two additional 150 MW units began in 1975. A conveyor belt running north to south from the Thunder Bay Terminal on McKellar Island to the generating station the northern third passes under the McKellar River with the rest passing above ground on Mission Island (Wylie-Bellhouse, 1981). The ownership of Mission Island is critical toward the restoration development and it has

been illustrated in Figure 1. The Federal Government owns the majority of the marsh; this land is administered by the Lakehead Harbour Commission. The City of the Thunder Bay owns the northernmost portion of the marsh in vicinity of the old landfill site. The Conservation Authority has a lease agreement with the City for this parcel of land. The city also owns property behind the western border of the marsh; this is under lease to Ontario Hydro for fly-ash and disposal from the Generating Station. Ontario Hydro owns the land to the south where the Thunder Bay Generating Station is located. A conveyor belt and access road extending north from the Hydro property along the western edge of the marsh. (Mission Island Marsh Master Plan, 1994)

MCVICAR CREEK

McVicar Creek (Figure 1) is the smallest of five major watercourses that flow through the city of Thunder Bay. The creek is a cold-water stream system tributary to Lake Superior that drains a total area of 50.65 km^2 with its outlet located in the Thunder Bay Harbor. The creek is approximately 16 km long and typically 2.5 to 3 meters in width with an average bank height of one meter immediately adjacent to the stream. The upper reaches of McVicar Creek are generally undeveloped and located mostly in forest open meadows, whereas the lower reaches are intensively urbanized. (Lakehead Region Conservation Authority, 1995)

ONTARIO PROVINCIAL WATER QUALITY OBJECTIVES

Provincial Water Quality Objectives (PWQO) are numerical and narrative criteria which serve as chemical and physical indicators representing a satisfactory level for surface waters and where it discharges to surface and ground water of the Province. The PWQO are set at a level of water quality which is protective of all forms of aquatic life and all

aspects of the aquatic life cycles during the indefinite exposure to the water. The Objective for protection of recreational water uses are based on public health and aesthetic considerations.

Provincial Water Quality Objectives are intended to provide guidance in making water quality management decision such as the designation of the surface waters of the Province which should not be further degraded. They are often used as the starting point in deriving waste effluent requirements included in Certificates of Approval and other instruments issued to regulated effluent discharges. They are used to assess ambient water quality conditions, infer use impairments, assist in assessing spills and monitoring the effectiveness of remedial actions. (Province of Ontario, 1994)

LAKEHEAD REGION CONSERVATION AUTHORITY

The early roots of the Lakehead Region Conservation Authority were first established in 1954. This Authority expanded its jurisdiction and was later constituted as the Lakehead Region Conservation Authority on January 1, 1963 under the Conservation Authorities Act by Order-in-Council 254/63. Authorities are responsible for effecting flood and erosion control the and conservation, restoration and development of renewable natural resources. (Conservation Authorities Act, 1946) The Authority receives transfer payments from the Province of Ontario administered through the Ministry of Natural Resources, as well as from the participating member municipalities. Additional partnerships and funding from private sector sources are also a regular basis. (Conservation Authorities Act R.S.O, 1980)

NORTH SHORE STEELHEAD ASSOCIATION (NSSA)

The North Shore Steelhead Association was formed on January 13, 1973, as a non-profit organization concerned with the conservation and preservation of fisheries in the tributaries of Lake Superior.

The association's primary concern is the protection and the enhancement of the north shore migratory Rainbow Trout fishery, but with the inclusion of all cold-water species in Thunder Bay region. The association's constitution stresses public education and close association with authoritative bodies includes the Ministry of Natural Resources and Forestry, Lakehead Region Conservation Authority.

As a non-profit organization, the North Shore Steelhead Association financial base is developed exclusively from fundraisings and donations from a various source of supporters.

GREAT LAKES SUSTAINABILITY FUND (GLSF)

Established by the Government of Canada, aims to help restore water quality and ecosystem health in Canadian Areas of Concern (AOCs). The Great Lakes Sustainability Fund provides funds and corporates with other agencies, industry and local community stakeholders to improve the ecosystem in AOCs.

THE CONSERVATION AUTHORITIES ACT

The Conservation Authorities Act was created by the Ontario Provincial Legislature in 1946 to ensure the conservation, restoration and responsible management of hydrological features through programs that balance human, environmental and economic needs. The Act authorizes the formation of Conservation Authorities.

THE CLEAN WATER ACT

The Clean Water Act is a law enacted by the Legislative Assembly of Ontario, Canada. The purpose of this Act is to protect existing and future sources of drinking water. The act is to protect existing and future sources of drinking water. (C.W.A 2006)

THUNDER BAY REMEDIAL ACTION PLAN

Thunder Bay has been discharging into the harbor primarily from the forest products industry in a long history. With the concern of the water quality and channelization of the North Shore of Lake Superior, the Remedial Action Plans was carried out. The Plan aims to clean up, solve pollution problems and restore wildlife habitat. (Info Superior, 2016)

MATERIALS AND METHODS

By studying and analyzing various restoration plans and projects around Thunder Bay areas, the understanding of restoration and its aspects, patterns, categorizations, related regulations, planning strategies are gradually building up.

RESEARCH QUESTIONS

I established a search strategy to identify the studies answering the following primary research questions.

In what circumstances should a site or region be restored?

This question implies the following key elements:

- Commercial values: the site or region that need to be restored to generate economy value.
- Aesthetic values: the site or region that need to be restored for aesthetic appearance.
- Biodiversity conservation: the site or region that need to be restored as a conservation planning reserve.
- Policy and legislation: the site or region that need to be restored according to certain policy or legislation.

How to evaluate a restoration project to see if the project is success or not.

This research question provides a guideline for this thesis, the characteristics of the successful restoration projects should be concluded during the study of the restoration projects of Thunder Bay.

Is there any commons or patterns among those restoration projects?

After study of those projects, is there any similarity within the projects, and what circumstances lead to that result.

RESTORATION PLAN: McVicar Creek Protection & Rehabilitation Plan

OVERVIEW & OBJECTIVES

The Project was led by the City of Thunder Bay with Carl Goodwin as the Process Engineer. The other contributors were: North Shore Steelhead Association, Lakehead University, Lakehead Region Conservation Authority, Province of Ontario, and Environment Canada. The plan aims to enhance and purify the McVicar Creek's water quality, with the consideration that the urban proportion of the creek could be contaminated by various source from the city. To achieve the objectives, a series of study and rehabilitation activities were taken in the McVicar Creek watershed.

The Great Lakes Water Quality Agreement – areas of concern, has included Thunder Bay region into AOC, which motivate this protection and rehabilitation plan. The overall goal of the plan is a healthy and sustainable watershed that contributes to the economic, environmental and social vitality of the city, while serving as a precedent for Thunder Bay and the greater Lakehead community. (City of Thunder Bay 2014)

PROJECT PROCESSES

The first step in the development of the McVicar Creek Protection & Rehabilitation Plan is Watershed Gap Analysis, which conducted the review of existing hydrologic, hydraulic water quality studies, and monitoring activities. This step aims to provide a foundation for the Protection & Rehabilitation Plan, identify issues, delineate the boundaries of the plan and identify gaps in the knowledge-base.

The issues identified in this stage of the process are as follows:

1. Hydrologic and Hydraulic Modeling is dated and limited in geographic extent. The primary goal of these modeling efforts was to delineate the floodplain of McVicar Creek.
2. A Stormwater Impacts Assessment was conducted for the resource in an effort to identify areas along McVicar Creek that were highly susceptible to stormwater impacts. This assessment, which was conducted in multiple phases, evaluated the resource, biotic health, in-stream water quality downstream of storm sewer outfalls, and land use of the contributing drainage area. The main findings included the identification of water quality parameters that exceeded Provincial Water Quality Objectives, the identification of three hot spot areas, and the development of stormwater remediation options for these hot spot areas. (City of Thunder Bay 2014)

   The main gaps in the knowledge-base are as follows:

   1. An evaluation of the existing water quantity and water quality data should be conducted to characterize flow regimes of the resource and to evaluate exceedances of Provincial Water Quality Objectives. This data should be used to conduct a baseflow analysis and evaluate the change in baseflow contribution with time.
   2. Limited fluvial geomorphology data is available on McVicar Creek and its tributaries. This information provides an important qualitative perspective on stream health and its stressors but lacks the quantitative morphology data necessary to assess stream channel stability and understand or predict the evolution of channel adjustment that must take place in response to anthropogenic or other external influences. This assessment will provide the City of Thunder

Bay with a better understanding of existing stream health, existing or potential threats, areas of concern, and specific resource protection needs.

3. No monitoring data for groundwater resources were identified. Given the groundwater-dependency of the resources, it is important to have a basic understanding of surface water and groundwater contributions to the resource. This will facilitate long-term management of the resource.
4. There is a lack of in-stream thermal monitoring data. This information could be used to gain a better understanding of surface water impacts.
5. The Hydrologic& Hydraulic Model is required to assess floodplain impacts.

The McVicar Creek Protection & Rehabilitation Plan identifies the issues and gaps in the knowledge-base with a various source of reference, not only the regulation such as the Provincial Water Quality Objectives were being followed as a threshold of water quality; but also, many case studies of similar projects were being considered as references that implemented in this project. For instance, a new water quality standard in development by the Minnesota Pollution Control Agency proposes a TSS standard of 10 mg/L for streams supporting coldwater fish, such as Rainbow Trout and Brook Trout which are common to McVicar Creek. This standard has also been used in McVicar Creek as the threshold for the proper fish habitat condition.

The second step of the development of the plan is Water Quality & Quantity Trend Analysis. During this step, the water quality data were collected from McVicar Creek at Cumberland St. N. The flow data between 2008 to 2011 was provided by the City of Thunder Bay. The pollutants that exceed the threshold of Provincial Water Quality Objective were selected as important subjective and illustrated through Figure 1-8. After

the analyzation, it found that higher concentrations of ammonium and phosphorus typically occur under conditions of higher stream flow, such as during spring snowmelt, while higher concentrations of chlorides and metals typically occur under summer baseflow conditions. Very few water quality samples were collected during summer and fall rainfall events (precipitation > = 10 mm during a 24-36-hour period), so it is unclear whether the dominant source of pollutant loads originates during spring snowmelt, baseflow, or peak rainfall event flow conditions. (City of Thunder Bay 2014)

The information collected during this stage were not meet the expectation, because only a few water quality samples were collected during summer and fall rainfall event. Thus, the proponent cannot identify the dominant source of pollutants; and might influence the effectiveness of the measures that aim to mitigate or prevent pollutions.

KEY ISSUES

There were four major issues raised during the development of McVicar Creek Protection & Rehabilitation Plan: lacking surface & ground water protection; stormwater runoff; stream crossings; channel alteration and manipulation.

The lacking surface and groundwater protection of McVicar Creek was a critical issue in the upper watershed of the creek. The condition of headwater has a significant impact on the health of the whole stream system. The unregulated development and industry were polluting the surface and groundwater especially in the upper watershed of McVicar Creek.

Stormwater runoff is a common issue that exists in most urban areas. The impervious surface in urban constructions increase the flow velocity of rainwater and snowmelt cross landscape; thus, alter the stream flow and increase flooding, destroy the

natural condition of the stream system and aquatic ecosystem. The stormwater management in Thunder Bay was blank in the planning phase of this Plan.

Stream crossing was also a critical issue refer to the health of the stream system. Due to the poor design and lack of consideration for the proper stream function, a great part of the McVicar Creek system cannot function naturally. The stream crossing problem was observed and classified into four categories: undersized crossing; shallow crossing; perched crossing; and insufficient culvert length.

Channel alteration and manipulation as another key issue was also identified in the urban portion of the McVicar Creek. The Unified Stream Assessment, completed by Lakehead University in 2010, identified both channel revetment (rock, gabions, concrete and other “hard armor”) and native vegetation removal with some frequency. (City of Thunder Bay 2014). Many sections of McVicar Creek have been altered due to the need of drainage and flood control, which in this way, the floods reduced but increased the pollution to the river system.

PRACTICES EVALUATION

Throughout the study during the planning, it indicated that if McVicar is to be preserved and even rehabilitated, the City of Thunder Bay needs to adequate ability to manage stormwater sufficiently, and discharge the stormwater properly to avoid pollution.

STRATEGY

The strategies for restoring and rehabilitate McVicar Creek can be divided into three categories: understanding the resources; projects and programs; and policy and education.

For understanding the resources, long-term data analyzing; watershed model planning; and monitoring progress towards McVicar Creek are needed; and thus, it required the dedicated and long-term staffing and routine sampling. These monitoring and planning activities are expensive. However, can be effective for maintaining the proper functioning of the Creek, and create cost saving in terms of long-term sustainability.

The long-term planning and monitoring of McVicar Creek can stimulate other restoration projects as it provides useful information for the watershed. The steering committee has identified various unique projects, and these projects are intended to serve as stream and watershed restoration for the Lakehead Region.

PLAN CONCLUSION

The McVicar Creek Protection & Rehabilitation Plan began in 2014, the major construction of rehabilitation operations was around Algoma Street South and McVicar Street. The construction of that area did not solve all the issues along McVicar Creek, but it serves as a good example for the restoration of the habitat within the Creek's watershed.

Many issues regard to the restoration progress in the Lakehead Region were carried out with this Plan. Firstly, Thunder Bay as an area of concern is lacking data collections for many ecological-important regions such as McVicar Creek. This insufficient knowledge can lead to the delay or inefficient of the restoration project's planning.

Secondly, during the planning phase of this Plan, the City of Thunder Bay did not have stormwater management. The stormwater management issue in Thunder Bay has been identified as a priority in the Plan, thus, it stimulates the Thunder Bay Stormwater Management Plan in 2016; which carried out numerous restoration projects regard to the stormwater management.

RESTORATION PLAN: City of Thunder Bay Stormwater Management Plan

OVERVIEW & OBJECTIVES

With the concerns that urban stormwater runoff and discharge to Lake Superior has adverse impact on the water quality of Lake Superior; stimulations from other restoration projects including the McVicar Creek Protection & Rehabilitation Plan; Thunder Bay as an area of concern (AOC); and lack of stormwater management in the City; the City of Thunder Bay carried out a 20-year plan for Stormwater Management Plan in 2016.

The overall objective of the Storm Water Management Plan (SMP) is to guide the City of Thunder Bay in the development of the stormwater management program that meets the Province's standards. The City has developed an approach to improve the stormwater system over the next 20 years and the guide includes identifying additional capital works, incorporation Low Impact Development and Green Infrastructure where appropriate, and recommends changes in the standards and By-Laws to green the community, to promote liveability and build resilience into the system in the face of changing climatic conditions. (City of Thunder Bay Stormwater Management Plan Vol. I. 2016)

PLANNING PHASE

The plan lists 14 previous plans that assist the development of SMP including the McVicar Creek Protection & Rehabilitation Plan; and Thunder Bay Remedial Action Plan. The preparations of federal legislation, provincial legislation, municipal regulation and Class Environmental Assessment Process has completed in this stage.

CARRIED-OUT PROJECT: Winnipeg Avenue Green Infrastructure

The Winnipeg Avenue Green Infrastructure competed in 2018, and it is the most recent project under the SMP. The project redesigns the sidewalk area (Figure 21) alone the Winnipeg Avenue and the utility area (Figure 21) in the corner of Beverly Street and Winnipeg Avenue. The existing stormwater drainage system alone Winnipeg Avenue were installed with the draintile cleanout structures and the knife gate valves (Figure 22). The constructions of bioretention basins and outlet control structures (Figure 23) located at the utility area as shown in Figure 21. The description of the outlet control structure, draintile clean out structure, knife gate valve, and bioretention basin are illustrated through Figure 24-27.

The Winnipeg Avenue Green Infrastructure improves the stormwater quality around that area, and it works synergistically with the Beverly Bioretention Development and the Memorial Biofiltration Development to improve the stormwater quality in larger spatial scales. With the strategy of Low Impact Development (LID), the management of stormwater pollution has mitigated the impacts of stormwater from the source of the pollution, mitigate the pollution by constructing advanced stormwater control structures and enhance the existing drainage structures.

PLAN CONCLUSION

As a 20-year plan, the SMP in Thunder Bay has just started, with many potential construction sites and many issues to encounter. The plan still needs to enhance in various aspect over time. Referring to Mr. Werner Schwar the supervisor of parks & open space planning, City of Thunder Bay, the implementation of the plan through projects are falling behind the schedule due to lack of professionals for project design and planning.

Thunder Bay as the city that just begins with the management of stormwater, still have to go through a learning curve. The education of professionals in stormwater management and the practice of construction operations both required times to build up the proficiency. After the period of learning and practice, there should be a significant increase in the progress of planning progress and operation progress.

RESTORATION PROJECT: George Creek Brook Trout Rehabilitation Project

OVERVIEW & OBJECTIVES

The George Creek Brook Trout Rehabilitation Project was operated by North Shore Steelhead Association, with funding provided by the Great Lakes Sustainability Fund. The other contributors were: Hatch Mott MacDonald, Fisheries and Oceans Canada, Thunder Bay District Stewardship Council, City of Thunder Bay, Province of Ontario. The project was carried out in 2013, due to the concern of the degraded brook trout nursery stream located in Centennial Park and was modified from its natural condition during the construction of the park. The project was about restoring the natural channel aspect of George Creek, so it can provide a suitable condition for brook trout nursery; thus, recover its degraded population.

PRE-RESTORATION WATER QUALITY CONDITION SURVEY (2013)

A survey of water quality conditions of George Creek was done by Michael Barten from Lakehead University in 2013. The survey provides a comprehensive measure of water quality conditions

, and compares the result to Canadian Environmental Quality Guidelines for Aquatic Habitat. The water quality throughout the entire creek is adequate, and in some cases excellent for brook trout, rehabilitation will potentially improve access for trout and habitat for other aquatic life. (Michael 2013)

The survey illustrates the creek condition prior to the restoration project. The George Creek Brook Trout Rehabilitation Project shall only focus on the modification of the creek channel since the water quality is certified adequate for brook trout nursery.

PROJECT PROCESSES

The project started with the redesign of the stream channel, the old channel was identified not suitable for brook trout nursery due to rapid flow velocity, inappropriate stream bedding, and poor water quality. The redesigned channel (Figure 10) has a large flow velocity due to the modification of stream bedding. The three crests of riffle (Figure 10) create stable and tranquil water body for the juvenile brook trout. The steady water body also helps the sedimentation process of the suspended solids, and that provides better water quality for the brook trout nursery.

Lacking vegetation coverage along the stream was also a critical issue for the old stream design. The plantation of vegetation along the stream can prevent the erosion of the channel, and reduce disturbance to the fish habitat. The vegetation covers the soil along the stream provides nutrients to the aquatic ecosystem; also reduce the sediments in the water. The shrub plantation provides shades to the stream, adjust the water temperature for brook trout nursery. Figure 11 illustrates the locations and species for each individual plantation.

To modify the flow velocity into the ideal condition for brook trout nursery, the proponent used many techniques besides redesign the river channel. Three logs were placed into the stream channel to provide cover for brook trout and reduce the flow velocity. One log wing deflector was placed at the upper portion of the stream to change the flow direction and enhance bank stabilization. These modifications were illustrated in figure 12.

The metal culvert in the stream (Figure 13) was unaesthetic and the metal culvert was rusted. With the concern of the heavy metal might contaminate the stream, the proponent replaced it by a wooden bridge (Figure 14).

FOLLOW UP AND MONITORING

Due to the property of the rehabilitation project, the condition of the creek is stable and not likely to encounter large disturbances. Thus, there is no routine follow up or monitoring process scheduled by the proponent.

PROJECT CONCLUSION

The George Creek Brook Trout Rehabilitation Project was constructed with the consideration to restore juvenile brook trout's habitat and recover its population, with the impetus of Thunder Bay as areas of concern. The construction of Centennial Park back in the 1960s lacked the concern of brook trout habitat, result in the George Creek brook trout population affected by a railway cross and a footpath. The population of brook trout in Lake Superior experienced a decline due to the overfishing, and throughout this rehabilitation project, George Creek has been providing increased number of juveniles which contributes the recovery of the brook trout population in Lake Superior.

With the re-design and modification of George Creek, better habitat for brook trout nursery was created. And the project also turned the unimpressive creek into a stream with high ornamental values across the Centennial Park.

RESTORATION PLAN: Mission Island Marsh Conservation Area Master Plan

OVERVIEW & OBJECTIVES

Began in the late 1800s, Thunder Bay had a series of alteration to the shoreline of Lake Superior. This led to the shoreline and harbor area handle a variety of commodities including grain, iron ore, steel products, coal, potash, sulphur, forest products and petroleum (Lakehead Harbour Commission, 1982).

The northeast corner of Mission Island was used by the City as a dump for over 20 years until 1965. And the south of the island was constructed a 100 MW coal-fired generating station in 1958; and two 150 MW generating stations constructed in 1975.

The restoration project of Mission Island Marsh Conservation Area was planned and operated by Lakehead Region Conservation Authority, with the master plan of Mission Island Marsh Conservation Area was published in 1994. The overall achieves and goals were: to help a public awareness of the ecological functions and values associated with Lake Superior's coastal wetlands; to provide passive day use recreational and outdoor educational opportunities in a manner compatible with the natural environment; to encourage the appropriate zoning and Official Plan designations required to obtain a permanently protected status for the marsh habitat (Mission Island Marsh Master Plan, 1994).

The Mission Islands Marsh shoreline and the bank of the McKellar River were designated as Open Space refer to the City's Official Plan.

BIOLOGICAL SIGNIFICANCE

Wetland has many ecological aspects, and significant to natural environment. A wetland contains a large amount of biodiversity also provides numerous ecological services including protect shoreline from wave erosion; reduce the impacts of floods; absorb pollution and purify water; provide habitat for aquatic nursery and waterfowl species.

The Mission Island Marsh found to be the only existing wetland in Lake Superior Thunder Bay Shoreline, and it plays important role for maintaining biological aspects around this region. Refer to Mission Island Conservation Area Mater Plan, Meadow Vole are the most common of the small mammals found on the marsh. Other included Arctic Shrew, Masked Shrew, Meadow Jumping Mouse and Heather Vole. Aquatic fur bearers on the island included beaver and muskrat; other fur bearers present include mink, red fox, coyote, raccoon, weasel, squirrel and snowshoe hare (Wylie-Bellhouse, 1981, 1982) Mission Island Marsh provides a wonderful habitat for various avian species. The area has been identified by biologists, field naturists and local residents as important for migrating species resting, feeding and staging, resting land and water-bird species and feeding, shelter and brood-rearing for most resident avian species of this area (Mission Island Marsh Master Plan, 1996). Table 1 illustrates the avian species counts for 15 observation areas in Thunder Bay region in 2018. The Mission Island Marsh (area 6) has an average total species of 13 and average total individuals of 150 in a 10-year period. Mission Island Marsh ranks 13rd of the average total species and ranks the least (15th) of the average total individuals. This result is reasonable when considering Mission Island Marsh is located at the middle of the city and surrounds by industry development areas.

Mission Island Marsh contains a large variety of both aquatic plant species and upland plant species. In the north of Mission Island, aquatic plants with high resilient are found here due to the influence of the wave actions from Lake Superior. The aquatic plant species in the south shows a reduction of wave resistance and population intensity. The dominant specie is soft-stem bulrush also with the existence of sedges, grasses, horsetails, burreeds and cattails; the floating vegetations are arrowheads, waterlilies and duckweed. The submered species include bladderworts, sedges, watermilfoil, water moss and pondweed; the pondweed is the most abundant and provides rich food resources for waterfowl. For the upland vegetation species, the marsh is dominated by tamarack and black spruce. Speckled alder and white birch are found in the dry land area of the island. (Mission Island Marsh Master Plan, 1994)

The Mission Island provides habitat for a large number of fish species. Longnose Sucker, White Sucker, Smelt, Spottail Shiner, Yellow Perch and Northern Pike are the most common of the species (Mission Island Marsh Master Plan, 1994). The marsh also serves significantly in the fish nursery. The juveniles of Pike, Longnose Sucker, Spottail Shiners, and Yellow Perch are found within the marsh.

HYDROLOGY & WATER QUALITY

Marsh as a type of wetland serves as natural filters for a wide range of chemicals and help to improve water quality. Dilution of water, onshore mixing and the complex hydraulic and biogeochemical transformation which occur in marshes all contribute to this (Mission Island Marsh Master Plan, 1996).

A dated study took by Lakehead Region Conservation Authority about the water quality in Mission Island Marsh indicates that the water status often climbed above the

Provincial standard of 100 Fecal coliforms/100ml, especially following heavy rain events. However, within the guideline recommendations issued by the Ontario Ministry of Health in 1993 where the indicator was Escherichia coli, the water quality results were within the Provincial limits. The indicator selection can be biased, especially with small numbers of indicators. The water quality of Mission Island did have significant improvement after 1993 since the discharge from pulp mills relocated.

CARRIED-OUT PROJECT: McKellar River Habitat Restoration Project

As the largest project under the Mission Island Marsh Conservation Area Master Plan, the McKellar River Habitat Restoration Project contributes significantly to the improvement of the landscape in the region. The objective of this project is to restore the natural ecosystem of McKellar River, provides a properly functioning ecosystem to support wildlife species.

The shoreline of Lake Superior in Thunder Bay region has been altered heavily by various human activities. Most often situation is to straighten or armor with concrete. Those actions have great adverse impacts on the productive zone along the shoreline that provide habitat for various wildlife species. The McKellar River was affected by the industrial constructions in the McKellar Island and the railway constructions along the inland shoreline of Thunder Bay.

The planning phase of the project began in 1993, operated by the partnership between Thunder Bay Remedial Action Plan and Lakehead Region Conservation Authority. The project construction began in the spring of 1994 with the excavation of two embayments on Mission Island along the south bank of the McKellar River, on either side of the Ontario Hydro’s underground coal conveyor (Mission Island Marsh Master

Plan, 1994). The project was funded by Federal and Provincial government through the Great Lakes Clean-up Fund and other partnerships.

Both embayments are approximately 1.5 ha in size and have a maximum water depth of about 2.5 metres with gradual sloping shorelines. The shallowness of these bays is expected to allow faster warming in the spring and their inlet design should provide the necessary protection from waves needed to establish aquatic vegetation. A number of high spots were retained to form islands within the new bays and additional trees and shrubs will be planted around the bays to provide shade and cover. In addition, a variety of substrate types from organic soil to gravel and boulders were placed within the water and along the shoreline to diversify fisheries habitat. Each bay has also been designed with a wide opening at the mouth to maximize water exchange and prevent stagnation. Both of the embayment shared similar habitat characteristics and appearance, however, the restoration strategy was different where the west one was seeded and planted with a variety of wetland species and restored the site quickly, and the area within Mission Island Marsh Conservation Area was left alone to regenerate naturally without human intervention. (Mission Island Marsh Mater Plan, 1996)

With simple visual comparison of the two embayments in October 2018, the west embayment which restored by artificial plantation had a higher density of vegetation compare with the adjacent east embayment that regenerates naturally (Figure 17). This reflects a common situation in many restoration projects, whether chose the artificial method with comparable higher efficiency and cost or use natural establishment with low efficiency and cost.

EDUCATION

Education of public's awareness of wetland as one of the objectives of the Mission Island Marsh Conservation Area Master Plan, constrictions such as wildlife viewing station, feeding stations, viewing mound rail attachment was constructed. To modify the marsh for public access, the construction of benches, waste receptacle, entrance road, parking area, trails, and interpretive pavilion also followed up.

The Mission Island Marsh provides the easiest way for Thunder Bay residents to access to wetland ecosystem, observe migratory avian species, and the Mission Island Marsh is the only place in Thunder Bay where can provide observation of fish nursery for Thunder Bays.

SHORELINE EROSION

Shoreline erosion is a natural process that mainly caused by the wave action, result in the shrink in size of the inland area along the shoreline. The shoreline erosion in Mission Island primarily happened in the eastern coast of the island, the shoreline erodes with the average speed of 4 inches yearly. The boardwalk was constructed in 1995 on the inland areas along the east coast of the Mission Island, under the effect of shoreline erosion, the boardwalk is now locating on the waterbody (Figure 18). The Lakehead Region Conservation Authority is making a decision with public participation in the solution to this situation. The decision needs to make that whether left the shoreline along and let nature do the thing or implement shoreline protection constructions. The shoreline erosion will eventually erode a large area of the eastern side of the island, impact the functionality of the sightseeing; whereas the implementation of shoreline protections will carry out a large amount of cost and affect the appearance of the marsh.

PLAN CONCLUSION

The Mission Island Marsh Conservation Area as the only existence of Provincial Significant Wetland, it provides numerous ecological services and supports a large variety of wildlife communities; and offers the public the opportunity to understand the importance of wetland ecosystem. This Mission Island is one of the most successful and popular recreation sites in Thunder Bay, attracts people around Thunder Bay to spend their time in this wetland ecosystem.

The Mission Island Marsh Conservation Area has been visited by numerous school groups and local residents, the traffic report of Mission Island in 2016 by Lakehead Region Conservation Authority (Figure 19 & 20) indicates the monthly average vehicle enters Mission Island. According to the report, there were 52,633 vehicles entered Mission Island in the year of 2015.

The McKellar River Restoration Project considered to be the leading project under the Mission Island Marsh Conservation Area Master Plan, and it has restored the ecosystem for a large portion of the Mission Island Marsh. The two embayments of the restoration project also offered the demonstration of before and after monitoring of the biological and chemical characteristics of the area to compare the costs and efficiency of artificial versus natural establishment of aquatic vegetation (Mission Island Marsh Master Plan, 1994). And this offers the opportunity to communities, research institutions, or other parties to further study habitat restoration technique and increase the overall understanding of the wetland ecosystem.

LAND USE POLICY IN THUNDER BAY

"The Official Plan is the principal land use document for the City of Thunder Bay. It is a formal statement by Council of land use goals, objectives, and policies, intended for the guidance of public and private development decisions within the City of Thunder Bay. It shall form the basis for decisions regarding the City's Zoning By-law, other land use controls, and future planning initiatives during the 20-year life span of this Plan."

------*City of Thunder Bay Official Plan, 2002*

The Plan categories the lands in Thunder Bay into seven categories to increase the effective, efficiency and consistent on decision making and administration of land use. With this establishment of land use category, it offers a straight and clear usage of land to the corporations and communities. Thus, it promotes the development of multiple approaches management and stimulates economic growth in Thunder Bay.

Three of the seven categories (Environmental Protection Areas, Open Space Areas, Rural Areas) that are related to the topic of this thesis will be introduced.

1. Environmental Protection Areas

Strategic objectives:

- preserve and enhance the natural environment
- preserve the unique attributes of the local physical landscape
- preserve and enhance fish and wildlife habitat, as well as flora environs; and,

- reduce the potential for public cost or risk to City residents by directing development away from area where there is a risk to public health and safety or property damage.

Coverage:

- Natural Corridors
- Provincially Significant Wetlands
- Areas of Natural and Scientific Interest (ANSI'S)

2. Open Space Areas

Strategic objectives:

- Provide sufficient recreational opportunities, open space and park facilities within the City to meet the needs of residents; and,
- Achieve a highly integrated system of recreational areas and trails throughout the City.

Coverage:

- Public Recreation
- Private Recreation
- Use of Waterways
- Recreational Trail System

3. Rural Areas

Strategic objectives:

- Limit the amount of residential development so as to preserve the rural character of the area and protect the natural environment;

- Ensure that the amount of new residential development does no necessitate the extension of municipal services into the rural area, nor unduly require increases to the level of service currently provided; and,
- Protect and encourage the retention of viable farm operations by minimizing land use conflicts between agricultural and non-agricultural uses.

Coverage:

- Residential Development
- Secondary Uses
- Rural-Related Commercial and Industrial Activities
- Service Commercial Activities
- Non-Residential Use in Rural Areas

DISCUSSION

The relationship between nature and human is constantly changing, this occurs due to our understanding about nature is developing. Take the philosophy of nature as an example. From the early 19th century to nowadays, the philosophy of nature has gone through three stages. In the early 19th century, people dominate the nature and use all resources for our development; in the 20th century, people realized that development and expansion without conserving nature can result in serious hazards, thus came with the philosophy that nature dominates human; from the late 20th century until now, people are developing with the principle that human and nature are co-existent. Our current definition and understanding about nature have determined the fact that whenever human develops, there will be the restoration. Thus, there is an increasing frequency of restorations taken place.

By the study of the recent restoration projects and plans in the Thunder Bay area, it can be found that most of the restoration projects and plans were initiated by certain regulation or policy, and because of Thunder Bay is the largest city in Lake Superior, most of the restoration projects were established due to the concern of Lake Superior. The Mission Island Marsh Conservation Area Master Plan was planned under the 1987 Great Lakes Water Quality Agreement between Canada and the United States that listed Thunder Bay as Areas of Concern. The George Creek Brook Trout Rehabilitation Plan was funded by Great Lakes Sustainability Fund, which the GLSF aims to improve the water quality and ecosystem of Areas of Concern. The McVicar Creek Protection & Rehabilitation Plan was also imitated by Thunder Bay Area of Concern, and within the

development of the project, the realization of lack stormwater management in Thunder Bay area carried out the Stormwater Management Plan in Thunder Bay.

With the improvement of peoples living standard, people intend to live in a joyful environment, thus the demand of restorations has increased as well, however, due to the limitation of resources and funding, the supply of the restorations are very likely in shortage. Especially in Thunder Bay, where the development of the city focused on the industry in a long history and lack of funding compared with southern Ontario. By seeing the current restorations in Thunder Bay, the city still undergoes the early stage of restoration, by this, it means there are still many potential sites requires restoration operations, however, due to many restrictions on funding, public and profession education, the restoration progress in Thunder Bay is slow.

In order to improve and facilitate the current restoration progress in Thunder Bay, I suggest to look into this issue by implementing a community-based planning system, and the funding strategy. Finally, synergize those three topics together to form a mature and comprehensive system that covers the entire lifespan of restoration activity.

The community-based planning strategy begins with the identification of potential restoration projects in Thunder Bay, at this point, it is necessary to have public participation. The residents in Thunder Bay can report the issues directly to the related department, and the department is able to analyze the public demands combine with professional studies, and comes out with the list of potential restoration projects and its prioritization. After selecting potential restoration projects, the projects with low difficulties can begin planning in a community-based group. The community-based planning strategy is to distribute the practical restoration projects to the communities that

are capable of completing specific project. The research facility including Lakehead University and Confederation College are suitable for this strategy because the facility like those is able to provide professionals (Professors and faculty stuff) and education of professionals (students).

The community-based planning strategy has many advantages. Firstly, the community-based planning strategy can accelerate the restoration progress by sharing responsibility for small restoration projects for the government or professional organizations. Secondly, the community-based planning strategy offers an opportunity for people to get trained in this profession, thus, provide fresh blood to restoration sectors. For the people who get trained and practice their skill during the planning and operations could be hired by more professional departments or facilities and deal with more complex projects. Thirdly, the cost of operating the restoration projects will likely lower, due to the specialty of the educational facility like university or college, there is a lower even no cost in labor (students). Lastly, the community-based planning strategy attracts students for universities or colleges, with the hands-on practice and close relation to future employment, a large number of students will choose this program.

Beside implement of the community-based planning system, improving the efficiency and effectiveness of the restoration activities are also necessary to facilitate the restoration progress in Thunder Bay.

To achieve the efficiency and effectiveness of the restoration activities, the restoration projects should achieve the multiple approaches, that is to solve various environmental issues by single restoration projects and avoid creating new issues when trying to solve the existing issues. The Mission Island Marsh Master Plan has achieved

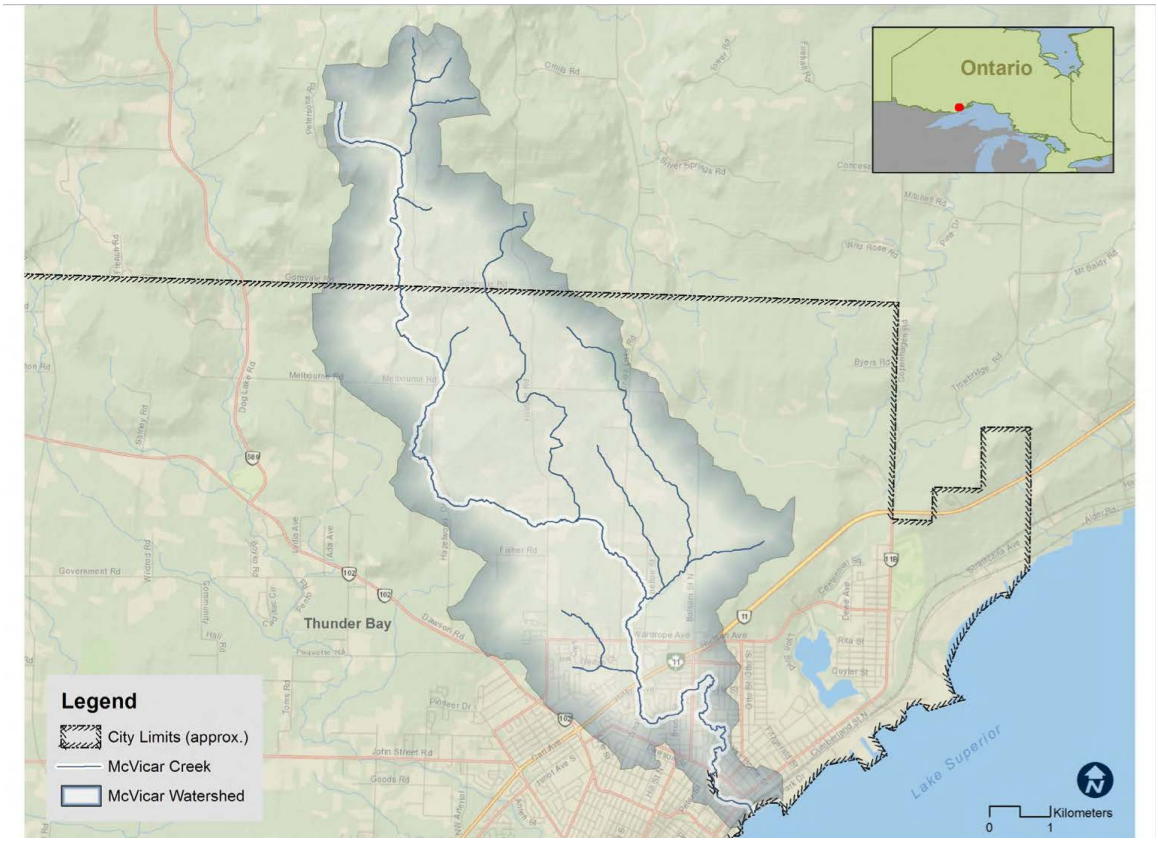
multiple approaches that restore the wetland habitats, provides recreation site for residents, and educates public the importance of the wetland ecosystem. The Centennial Park as a restoration and recreation site constructed without consideration of the protection of George Creek and thus results in the rehabilitation plan in 2013. Without considering the potential causes during the planning could lead to the decrease of effectiveness and efficiency of the restoration effort, and increase of the cost in the future.

CONCLUSION

By contrast and compare with Southern Ontario, the restoration progress in Thunder Bay are currently in the developing stage. Which means the improvement and facilitation of restoration progress in Thunder Bay are necessary. The development of restoration is costly; however, a good restoration could generate numerous benefits, in both directly and indirectly manner. The direct benefits are the various ecological services brought out from a wide variety of restoration projects, and the indirect benefits are many, the indifference of the scale of the restorations. For a small scale of restoration such as restore a utility area into a park; the indirect benefits could be a rise of housing price for adjacent neighborhoods. Referring to a larger scale of restoration, such as the improvement of the green infrastructure of the City of Thunder Bay, this will attract an increasing number of people to move in the city; thus, the city will likely to experience a growth in the economy. In consideration of the current restoration development in Thunder Bay, great potential of rapid development is upon the nearly future, and restorations are the keystone to achieve this.

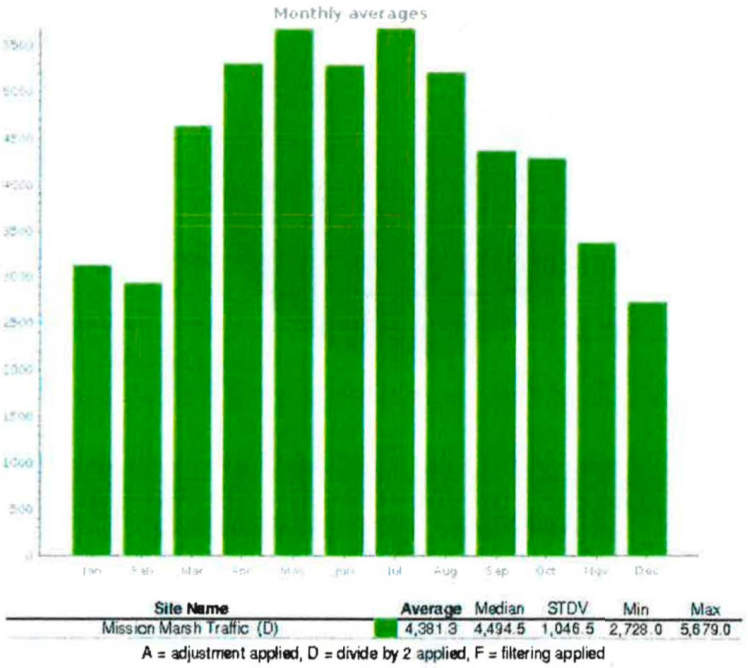
With the implementation of the community-based restoration system, and the multiple approaches restoration objectives, the progress of restoration in Thunder Bay should be enhanced significantly. However, those proposals are still theoretical, there are many restrictions in policy and regulation that reduce the feasibility of implementation.

APPENDIX



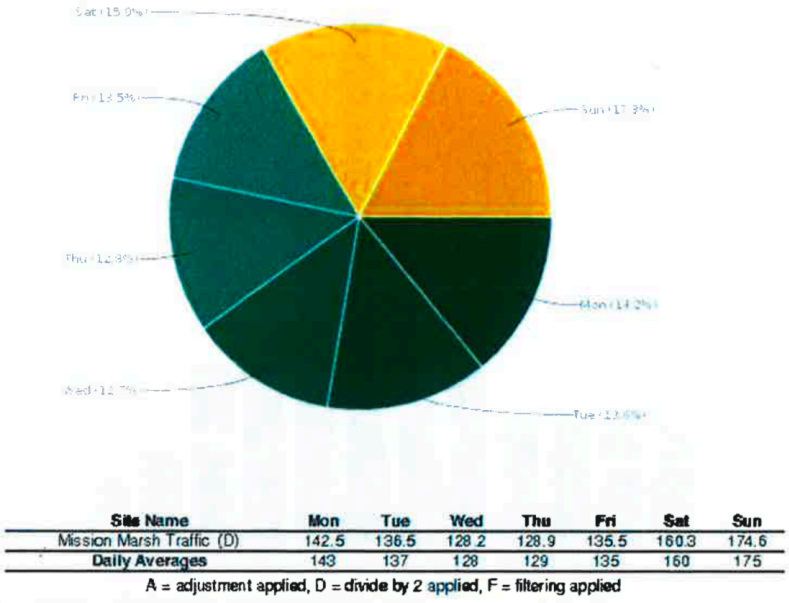
(Source: City of Thunder Bay, McVicar Creek Protection & Rehabilitation Plan)

Figure 1. Map of McVicar Creek Watershed.



(Source: Lakehead Region Conservation Authority Traffic Counter Report, 2016.)

Figure 19: Mission Island Marsh Monthly Average Vehicle Counts

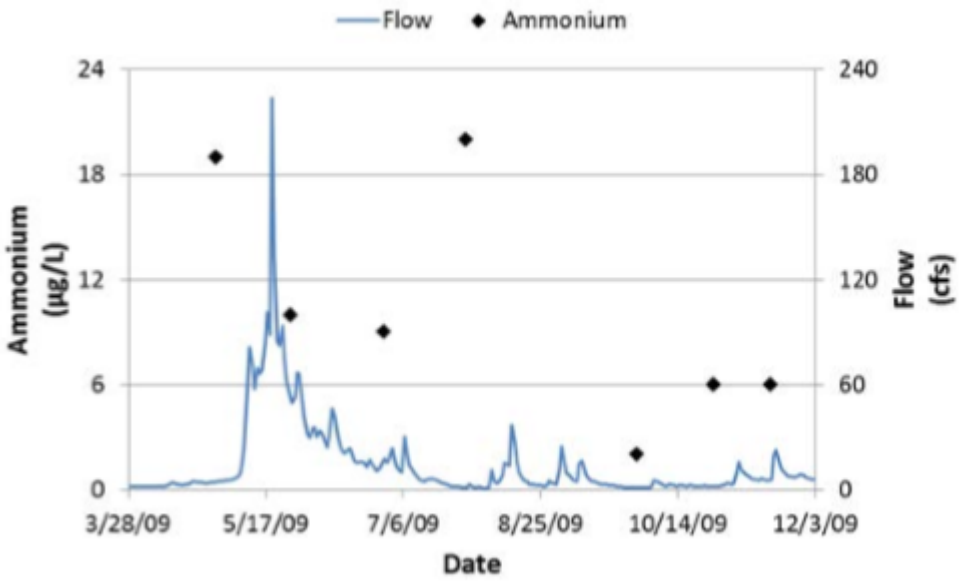


Site Name	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Mission Marsh Traffic (D)	142.5	136.5	128.2	128.9	135.5	160.3	174.6
Daily Averages	143	137	128	129	135	160	175

A = adjustment applied, D = divide by 2 applied, F = filtering applied

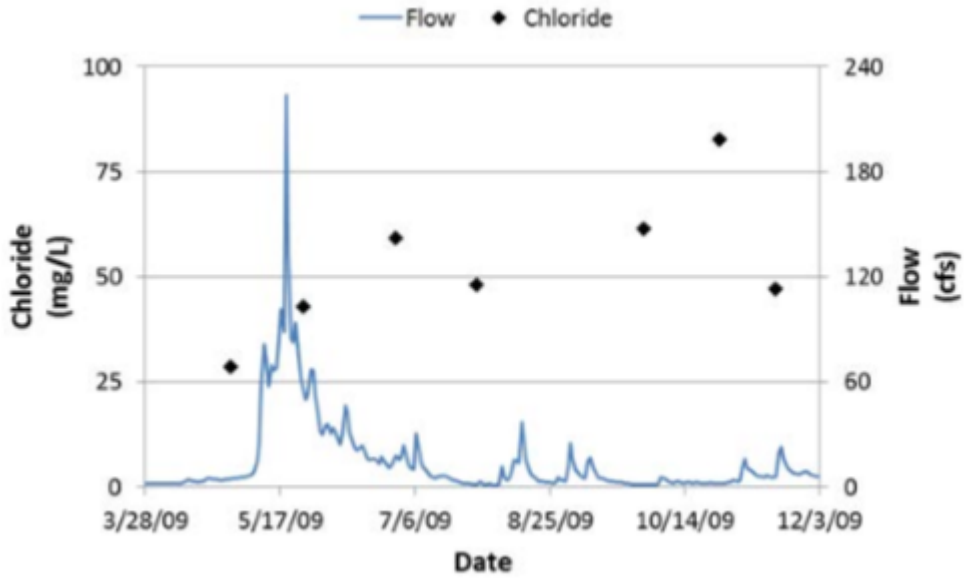
(Source: Lakehead Region Conservation Authority Traffic Counter Report, 2016.)

Figure 20: Mission Island Marsh Daily Average Vehicle Counts.



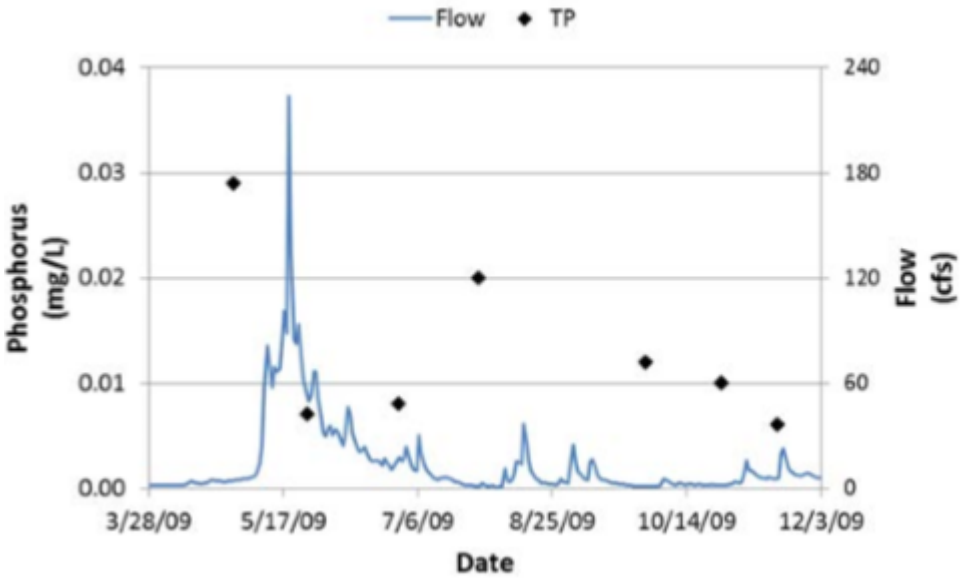
(Source: McVicar Creek Protection & Rehabilitation Plan.)

Figure 2. Seasonal patterns of ammonium concentration and stream flow in McVicar Creek, 2009.



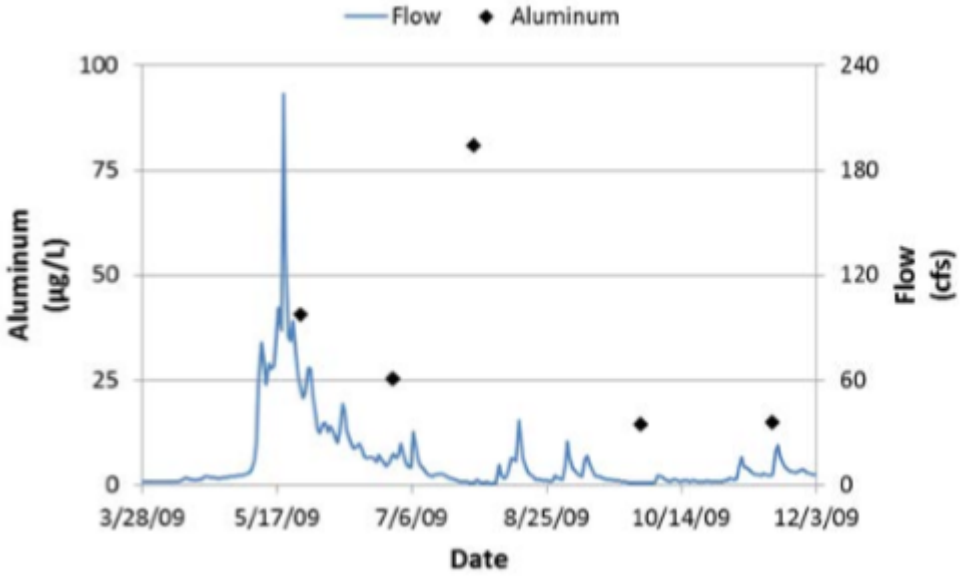
(Source: McVicar Creek Protection & Rehabilitation Plan.)

Figure 3. Seasonal patterns of chloride concentration and stream flow in McVicar Creek, 2009.



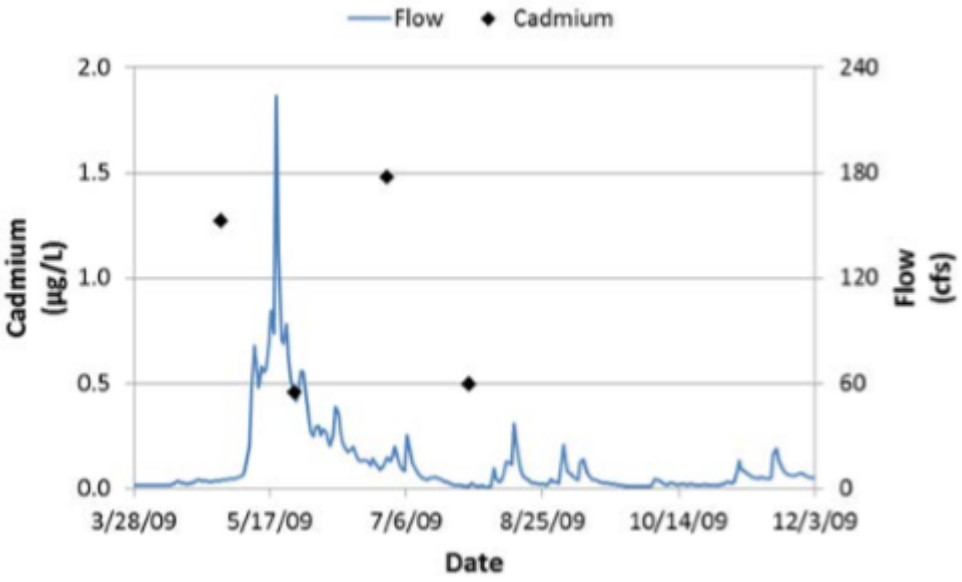
(Source: McVicar Creek Protection & Rehabilitation Plan.)

Figure 4. Seasonal patterns of Phosphorous (TP) concentration and stream flow in McVicar Creek, 2009.



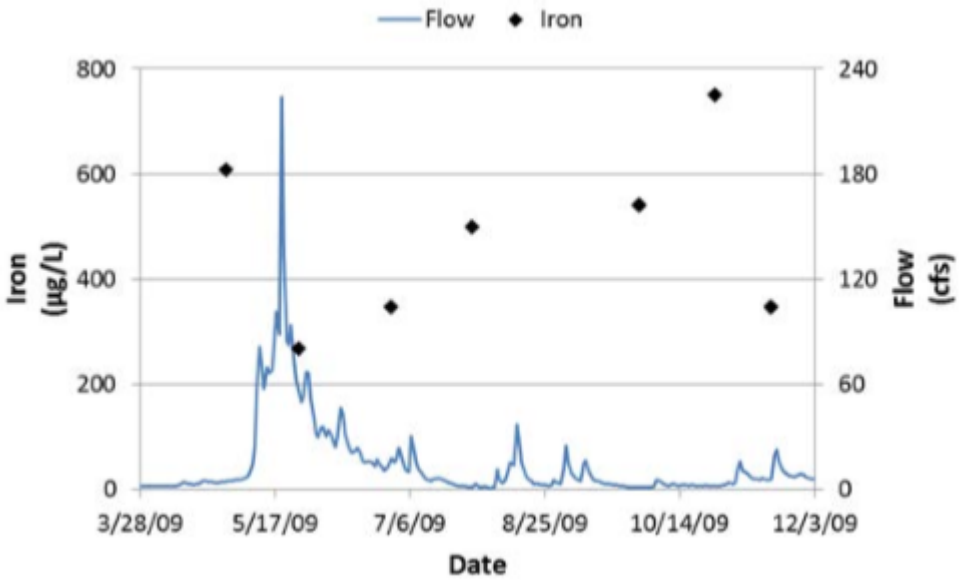
(Source: McVicar Creek Protection & Rehabilitation Plan.)

Figure 5. Seasonal patterns of aluminum concentration and stream flow in McVicar Creek, 2009.



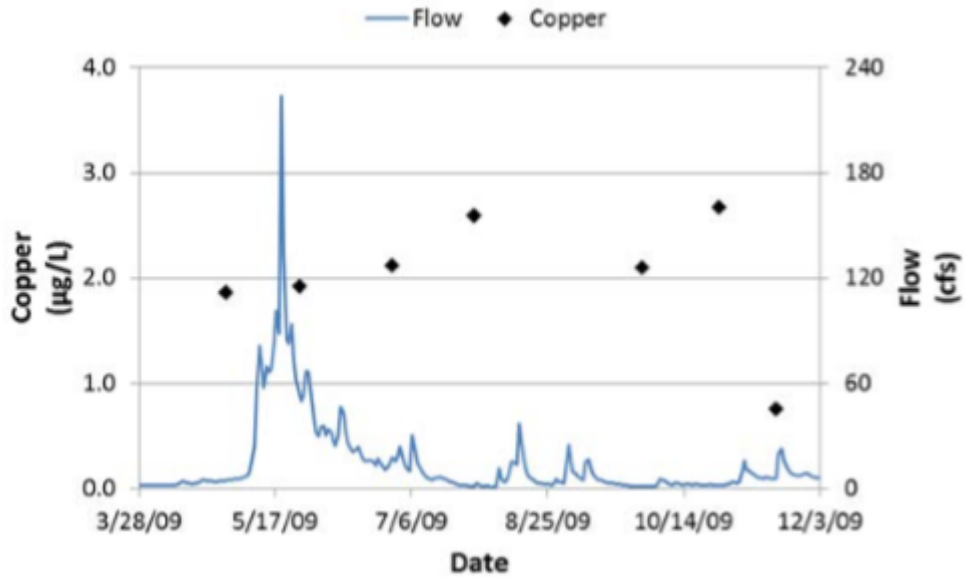
(Source: McVicar Creek Protection & Rehabilitation Plan.)

Figure 6. Seasonal patterns of cadmium concentration and stream flow in McVicar Creek, 2009.



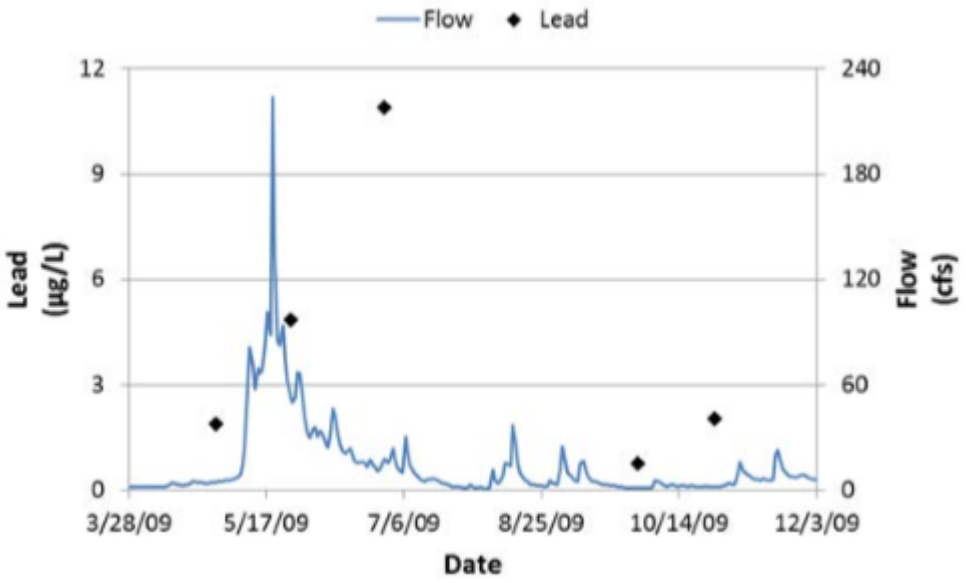
(Source: McVicar Creek Protection & Rehabilitation Plan.)

Figure 7. Seasonal patterns of iron concentration and stream flow in McVicar Creek, 2009.



(Source: McVicar Creek Protection & Rehabilitation Plan.)

Figure 8. Seasonal patterns of copper concentration and stream flow in McVicar Creek, 2009.



(Source: McVicar Creek Protection & Rehabilitation Plan.)

Figure 9. Seasonal patterns of lead concentration and stream flow in McVicar Creek, 2009.

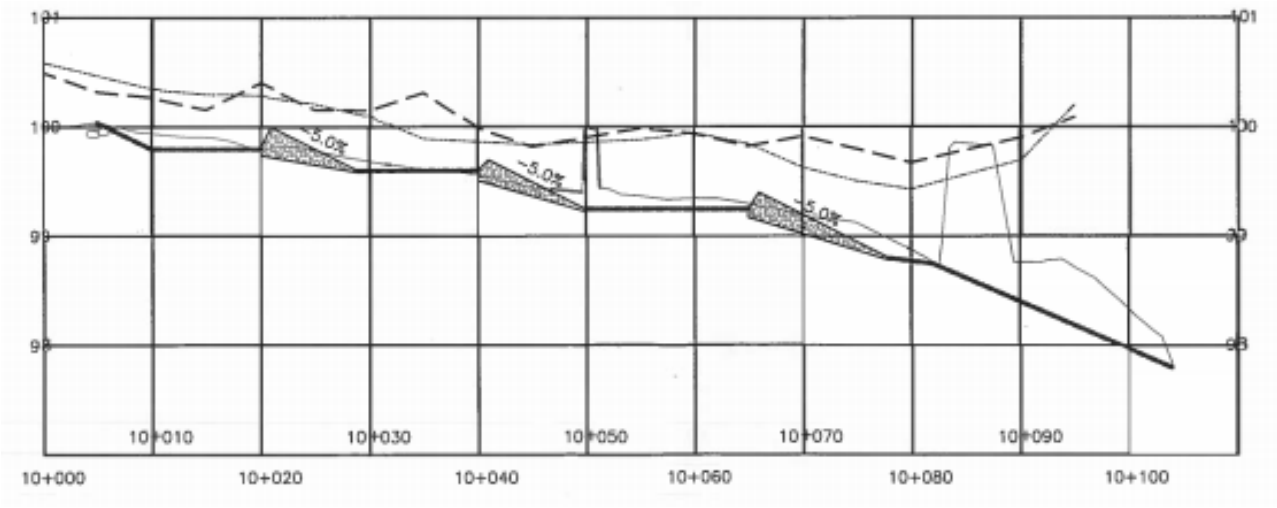


Figure 10. The George Creek redesigned channel bedding structure.

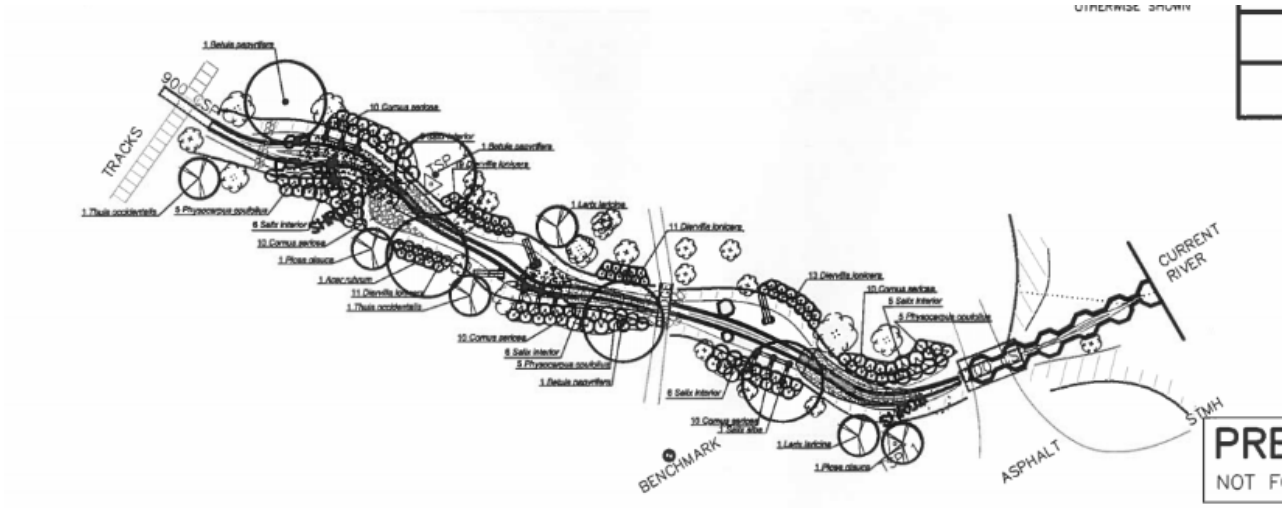


Figure 11. The reestablished vegetations of George Creek.

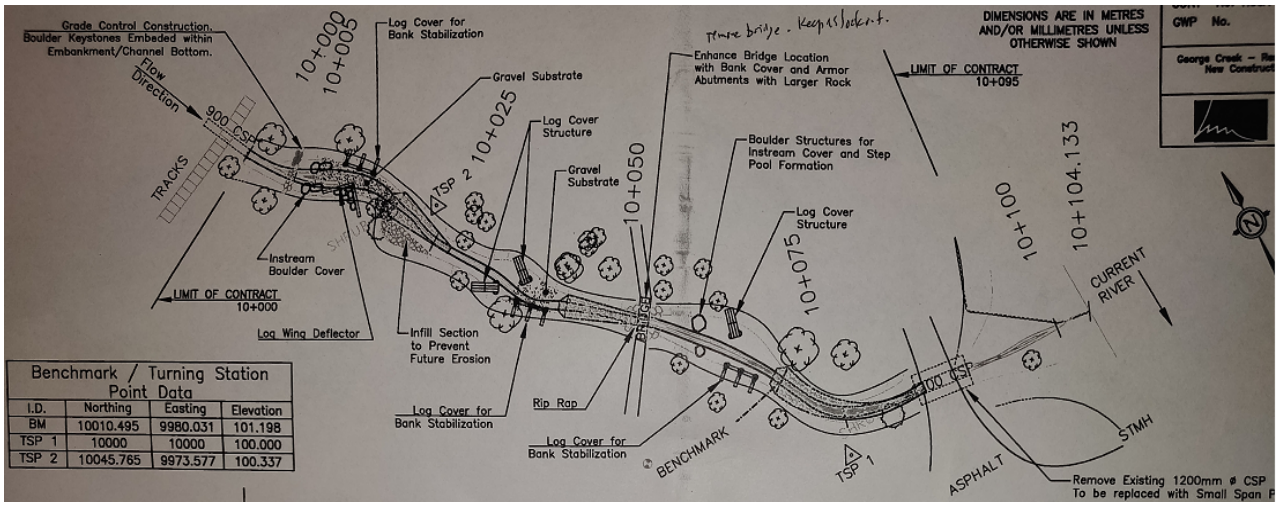


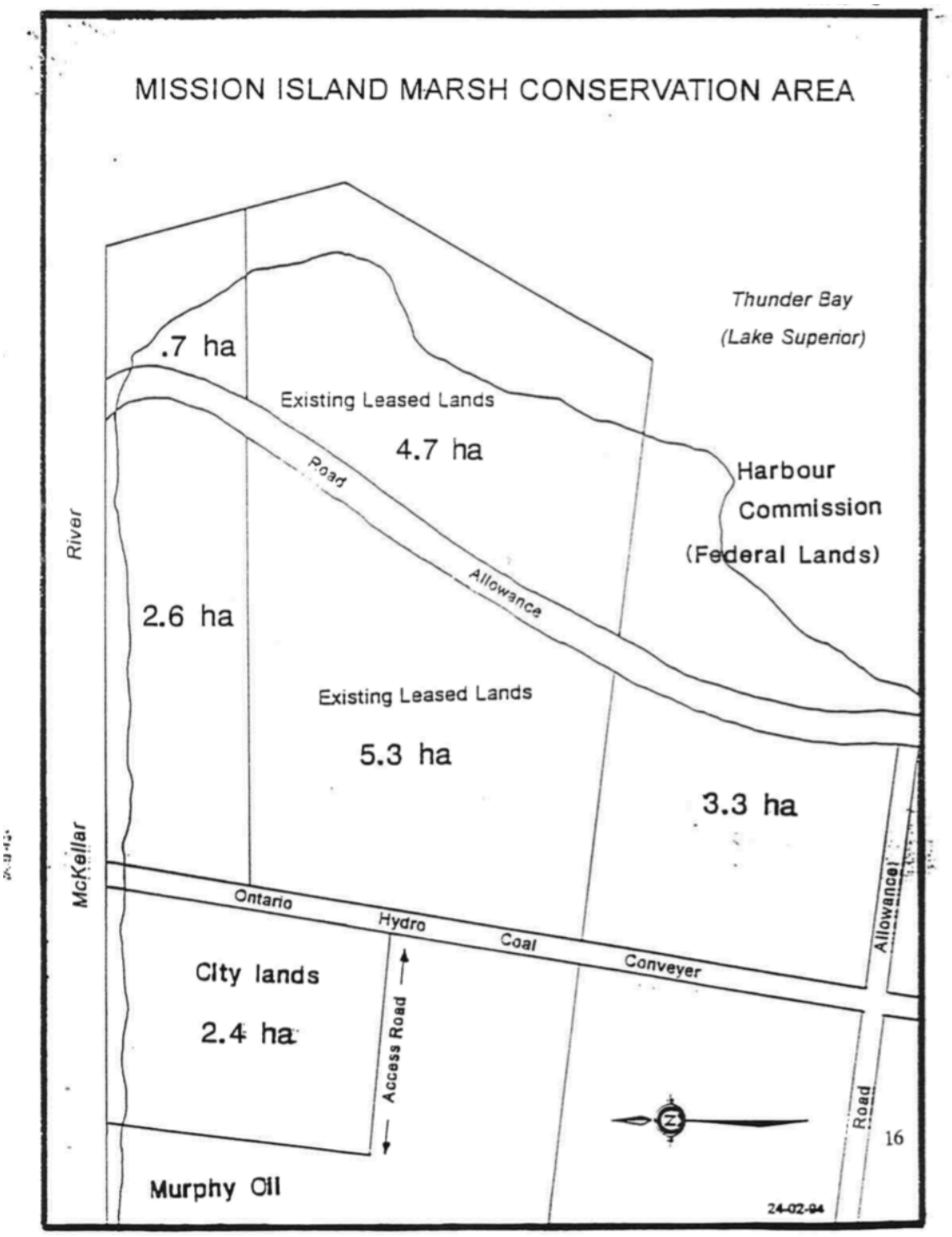
Figure 12. The George Creek channel modifications diagram.

(Source: North Shore Steelhead Association)

Figure 13. The metal culvert in the George Creek.

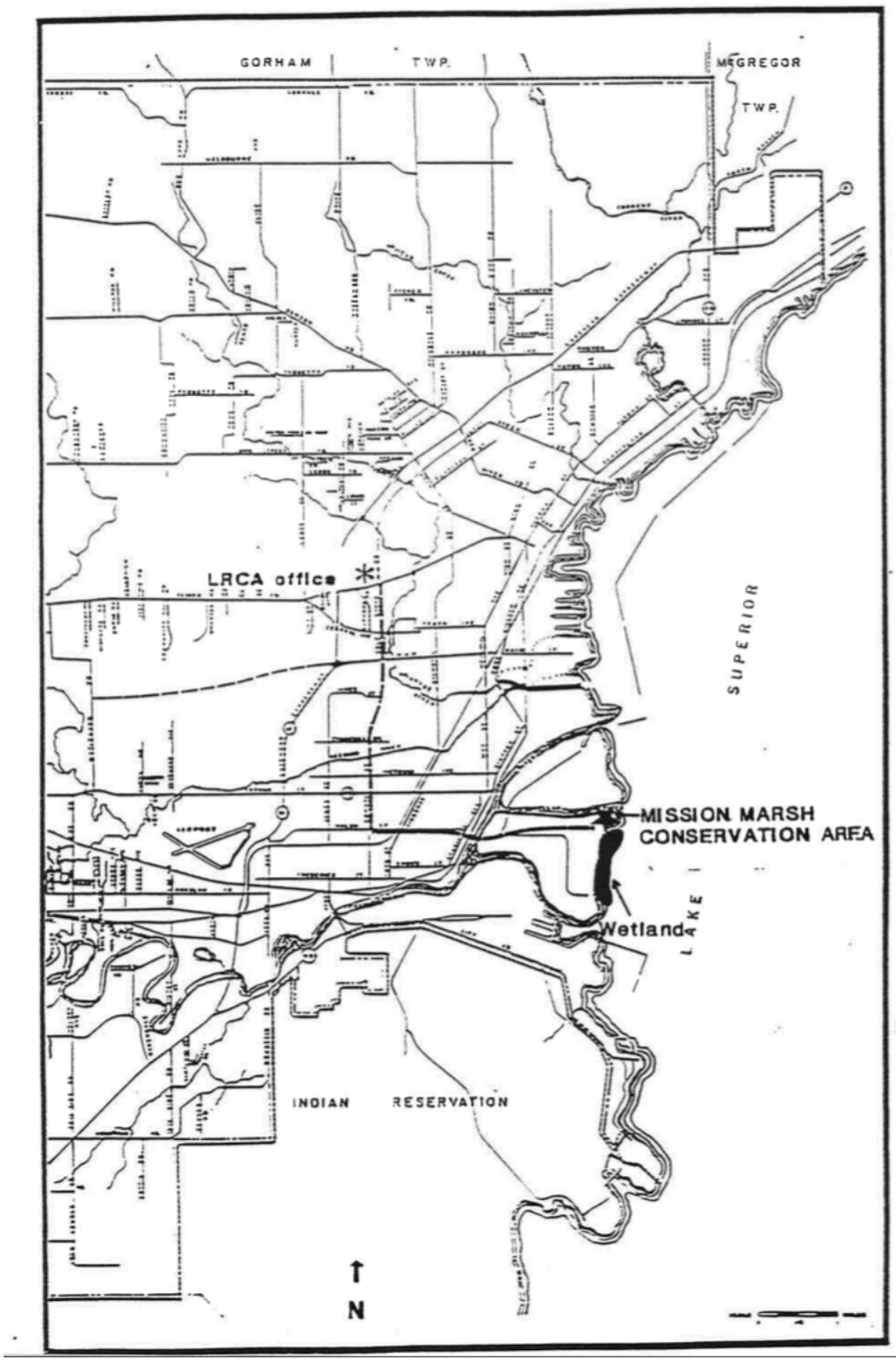
(Source: North Shore Steelhead Association)

Figure 14. The wooden bridge used to replace the metal culvert in George Creek.



(Source: Mission Island Marsh Conservation Area Master Plan.)

Figure 15: The map of land ownership of Mission Island Marsh Conservation Area.



(Source: Mission Island Marsh Conservation Area Master Plan.)

Figure 16: The map of Mission Island Marsh Conservation Area.

(Source: Shot by Yifu Yu, October 18th, 2018)

Figure 17. The two embayments of McKellar River Restoration Project, where the artificial site on the left and the natural establishment site on the right)

(Source: Shot by Yifu Yu, October 18th, 2018)

Figure 18. The Mission Island Boardwalk.

Table 1. 79th Annual Thunder Bay Christmas Bird Count (2018)

(Source: Thunder Bay Field Naturalists)

(Source: Shot by Yifu Yu, March 20th, 2019)

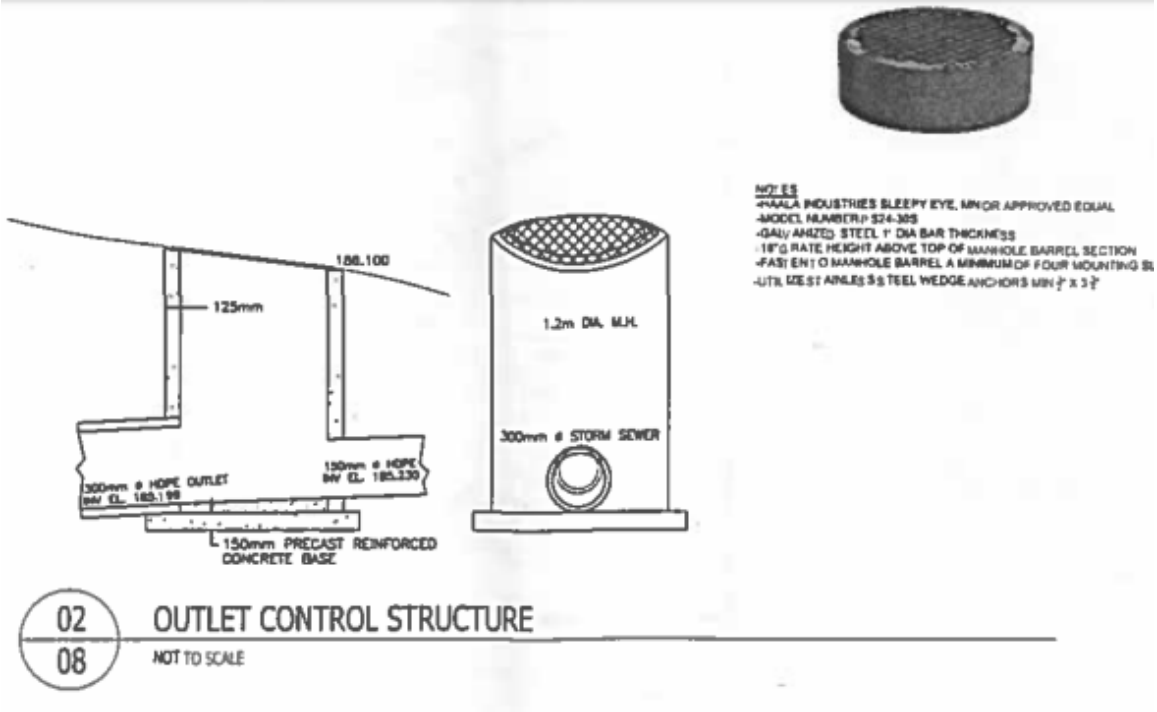
Figure 21. Winnipeg Avenue Green Infrastructure.

(Source: Shot by Yifu Yu, March 20th, 2019)

Figure 22. The photo of knife gate valve in Winnipeg Avenue Green Infrastructure.

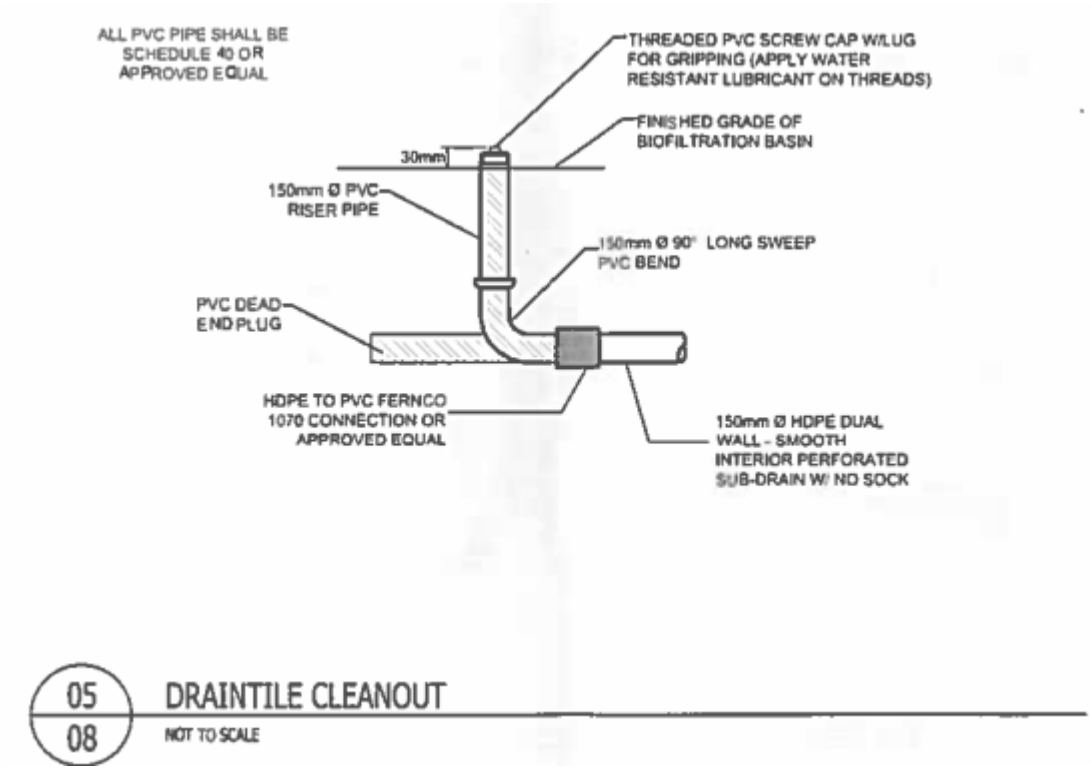
(Source: Shot by Yifu Yu, March 20th, 2019)

Figure 23. The photo of outlet control structure in Winnipeg Avenue Green Infrastructure.



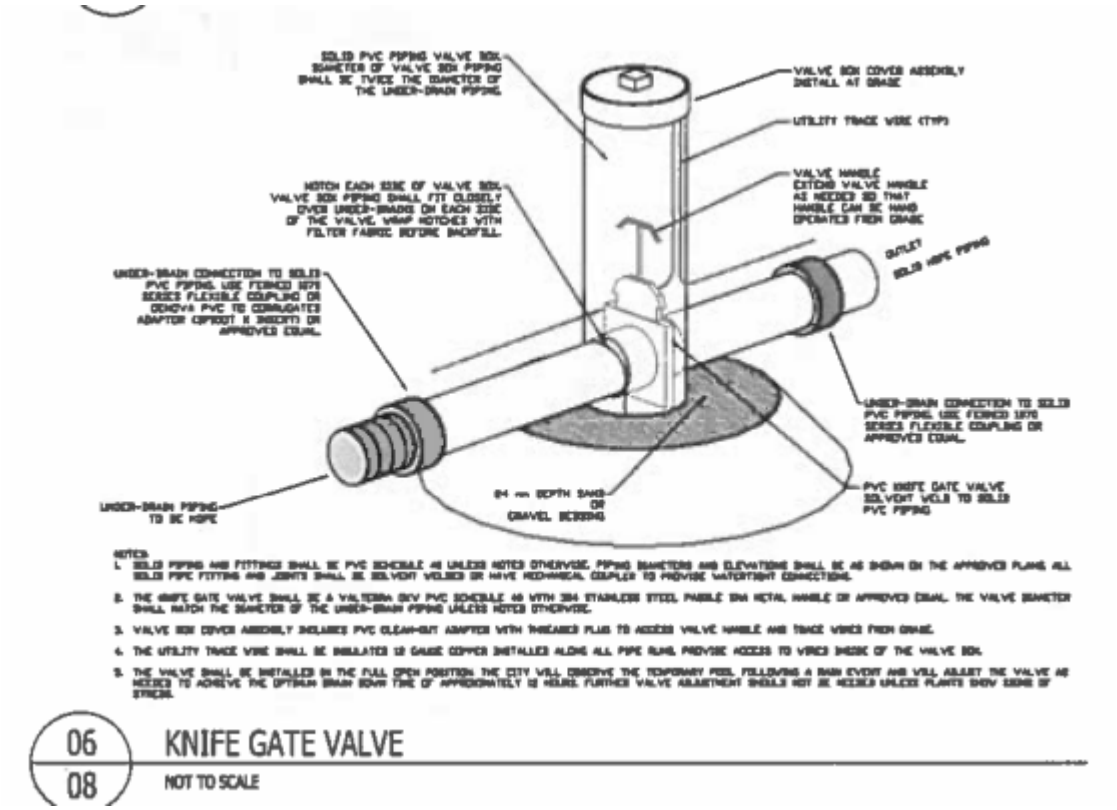
(Source: Shot by Yifu Yu, March 20th, 2019)

Figure 24. The diagram of outlet control structure.



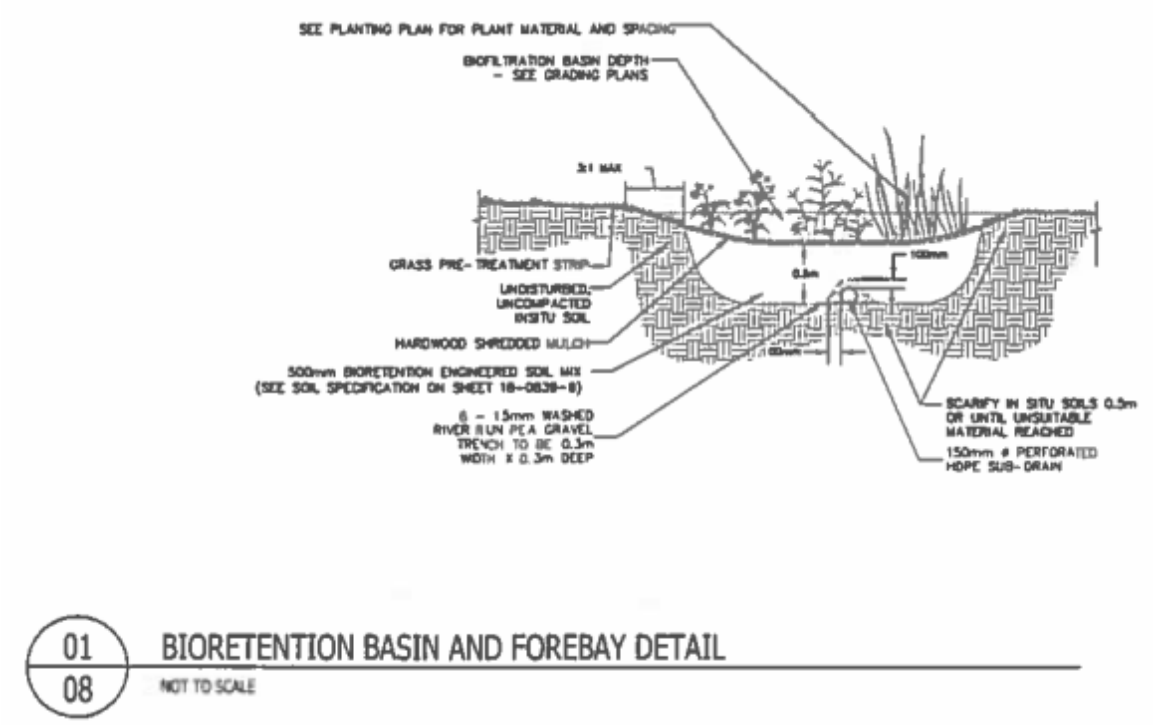
(Source: Shot by Yifu Yu, March 20th, 2019)

Figure 25. The diagram of draintile clean out structure.



(Source: Shot by Yifu Yu, March 20th, 2019)

Figure 26. The diagram of knife gate valve.



(Source: Shot by Yifu Yu, March 20th, 2019)

Figure 27. The diagram of bioretention basin.

79TH ANNUAL THUNDER BAY CHRISTMAS BIRD COUNT (2018)																	HISTORICAL				
Weather: Sunny, no precipitation	Wind: Light			Temperature:			High: -8.5 C (> 2017)					Low: -16.3 C (< 2017)									
SPECIES COUNT BY AREA	1	2	3	4	5	6	7	8	9	10	11	12	13	14	F	TOTAL	MAX	YEAR	#	#CW	LAST
Canada Goose						7										7	326	1987	17	18	2014
Common Goldeneye	1															1	170	1957	39	41	2016
Ruffed Grouse									1		2			1		4	28	1988	67	71	2017
Rock Pigeon	50	196	171	130	419	33	46	16	5	13	54	42	8	10	1	1194	2726	1973	76	76	2017
Mourning Dove											10		1			11	45	2010	26	29	2017
Herring Gull	25	106	18	3	14	27	3	5			450	6	34	12		703	5763	1987	70	73	2017
Iceland Gull											1					1	3	87/15	11	13	2016
Glaucous Gull											10					10	23	94/15	35	36	2016
Bald Eagle (HIGH)	6	5	4	1	4	2	6	8	5	14	103	7	3	1		169	246	2015	25	25	2017
Red-tailed Hawk									1			1				2	4	2001	16	22	2015
Rough-legged Hawk											1					1	9	2001	13	18	2016
Great Horned Owl (UNUSUAL)												1				1	2	43/15	9	15	2016
Barred Owl (UNUSUAL)												1				1	2	1998	7	7	2013
Long-eared Owl (NEW)											1					1	CW	10/16	-	1	2016
American Three-toed Woodpecker							1									1	5	2006	18	20	2017
Black-backed Woodpecker														1		1	5	00/01	23	27	2016
Downy Woodpecker (HIGH)	4	2	2	1	1	1	7	9	5	5	4	1	10	6	3	61	75	1992	75	75	2017
Hairy Woodpecker	5	3	2			1	3	3	4	5	5	3	2	5	2	43	58	1992	75	75	2017
Pileated Woodpecker (HIGH)	3				1	1	2	1		2	2	2	1	2		17	17	1987	51	58	2017
Merlin					2											2	5	2009	41	53	2017
Northern Shrike						1	1		1	1						4	6	2014	58	59	2017
Canada Jay	3								1		1		2			7	40	2006	77	79	2017
Blue Jay	6	1					15	11	19	12	8	2	9	4	2	89	154	1994	77	77	2017
American Crow	33	106	26	67	62	25	21	11	21	18	204	36	25	20	3	678	1564	2016	75	76	2017
Common Raven	22	3	6		6	2	51	21	9	35	352	49	7	12		575	1706	2001	75	75	2017
Black-capped Chickadee	69	44	41	23	47	46	71	29	28	118	81	63	40	74	14	788	1214	2003	78	78	2017
Boreal Chickadee (HIGH)	1				2		1						1	1		6	14	1951	50	56	2015
Red-breasted Nuthatch	5	3	11	4	8		1	1	3	11	14	4	5	5	4	79	286	2006	62	66	2017
White-breasted Nuthatch							2		1		1	1			1	6	21	2003	54	56	2017
Brown Creeper															CW	CW	4	4x	28	32	2017
Townsend's Solitaire (UNUSUAL)		1*	1*													1*	1	6x	7	9	2017
American Robin		3	3						1							7	229	1964	46	49	2017
European Starling	85	221	453	15	230	3	18	35	3		103	19	10	25	55	1275	4216	2003	79	79	2017
Bohemian Waxwing	85	7							11	6		6	5	10		130	809	1993	53	56	2017
Cedar Waxwing			CW		CW											CW	477	2005	30	34	2017
House Sparrow	32	188	63	16	228		6			1	30	62	11	58	54	749	3157	1971	79	79	2017
Pine Grosbeak	14	8	13		9		3	6	17	17	9		14	9	9	128	930	1954	79	79	2017
Common Redpoll	8	3	3		1		2		5	20		5			3	50	1066	1989	73	74	2017
Pine Siskin	21	14											6	4	3	48	1602	2005	54	56	2017
American Goldfinch	5				2			4		1			4		4	20	318	1994	27	30	2017
Song Sparrow (UNUSUAL)						1			1							2	3	1960	6	6	2014
White-throated Sparrow (HIGH)		2								1			1		1	5	8	94/15	29	30	2017
Dark-eyed Junco (Slate-colored) (HIGH)	3	2			10		2	3	2	1			4		3	30	47	1996	54	55	2017
TOTAL SPECIES (10-Year AVG - 47)	22	19	14	9	17	13	20	15	21	18	22	19	22	19	16	41	58	2006	<		2017
TOTAL INDIVIDUALS (10-Year AVG - 7718)	486	917	816	260	1046	150	262	163	144	281	1446	311	203	260	162	6907	16668	1994	<		2017
TOTAL SPECIES COUNT WEEK (10-Year AVG - 50)	508	936	830	269	1063	156	282	178	165	299	1468	330	225	279	178	43	61	2006	<		2017
SOME COMMON SPECIES MISSED IN 2018																	MAX	YEAR	#	#CW	LAST MISS
Evening Grosbeak																	670	1964	73	74	1956
Common Grackle																	48	1986	39	41	2016
Snowy Owl																	8	1993	35	50	2015
Purple FInch																	449	2002	34	37	2017
White-winged Crossbill																	293	2012	33	36	2017
Mallard																	654	1997	28	29	2017
																	MAX	YEAR	MOST SINCE		
Number of Volunteers	4	4	4	3	3	4	5	5	4	5	7	4	3	6		61	46	2016	2018		
Feeder Counters		1	1				1		1							4					
Total Number of KMs	46	60	61	22	100	24	67	65	75	75	135	121	57	51		959	1062	2010	2017		
Total Party Hours	7	7	8	7	8	4	6	8	8	8	11	8	6	8		103	126	2010	2010		

High/Low - >/< 1 SD of the average (AVG)	NEW = New to count week or count day	MAX = Highest count total	# = Number of counts
Unusual - Occurs with irregularity or rarely	F = Feeder counters	YEAR = Year of MAX count	LAST = Last year on count day or week
LAST MISS = Last year missed, including CW	CW = Count week	* = 1 individual bird in 2 areas	

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